Forces and Motion

PS-5 The student will demonstrate an understanding of the nature of forces and motion.

PS-5.1 Explain the relationship among distance, time, direction, and the velocity of an object.
Taxonomy Level: 2.7-B Understand Conceptual Knowledge

Key Concepts:
Distance, Direction, Displacement
Speed: Average speed, Instantaneous speed, Initial speed, Final speed
Velocity: Average velocity, Instantaneous velocity, Initial velocity, Final velocity
Rate

Previous/Future knowledge: In 5th grade, students summarized the motion of an object in terms of position, direction, and speed (5-5.2). In 8th grade, students used measurement and time-distance graphs to represent the motion of an object in terms of its position, direction, or speed (8-5.1) and also used the formula for average speed, v = d/t to solve real-world problems (8-5.2).
Physical Science requires that students expand on the idea that direction is an important aspect of the motion of an object. Students will compare the concepts of distance and displacement. The term "velocity" is used for the first time, and students will differentiate speed and velocity. The concept of how direction is an important aspect of motion is the basis for the study of vector motion in subsequent physics classes. Also, an understanding of the duel nature of velocity (speed and direction) is essential before students can understand how forces affect the motion of objects (Newton's laws of motion).

It is essential for students to

- Understand ***Distance and Displacement****:*
  - *Distance* is a measure of how far an object has moved and is independent of direction.
    - If a person travels 40m due east, turns and travels 30m due west, the *distance* traveled is 70m.
  - *Displacement* has both magnitude (measure of the distance) and direction. It is a change of position in a particular direction. For example: 40m east is a displacement.
  - *Total* or *final displacement* refers to both the distance and direction of an object's change in position from the starting point or origin. Displacement only depends on the starting and stopping point. Displacement does not depend on the path taken.
    - If a person travels 40m due east, turns and travels 30m due west, the *total displacement* of the person is 10m east.
    - If a person travels 40m east and then travels another 50m east the *total displacement* is 90m east.
- Understand ***Speed****:*
  - *Speed* is how fast something is going. It is a measure of the distance covered per unit of time and is always measured in units of distance divided by units of time. (The term "per" means "divided by")
  - Speed is a *rate* as it is a change (change in distance) over a certain period of time
  - Speed is independent of direction.
  - The speed of an object can be described two ways
  - *Instantaneous speed* is "the speed at a specific instant". *Initial speed* and *final speed* are examples of instantaneous speed. A speedometer measures instantaneous speed.

  - *Average speed* is "the total distance covered in a particular time period"
    - If an object is traveling at a constant speed, the instantaneous speed at each point will be equal to the average speed.
    - If an object is traveling with varying speeds, the average speed is the total distance covered divided by the total time.
- Understand ***Velocity****:*
  - *Velocity* refers to both the speed of an object and the direction of its motion.
  - A velocity value should have both speed units and direction units, such as: m/sec north, km/h south, cm/s left, or km/min down.
  - Velocity is a rate because it is a change in displacement over a certain period of time.
  - The velocity of an object can be changed in two ways:
    - The speed of the object can change (it can slow down or speed up).
    - The direction of an object can change. (A racecar on a circular track moving at a constant speed of 100 km/h has a constantly changing velocity because of a changing direction of travel.)
  - The velocity of an object can be described two ways:
    - *Instantaneous velocity* is the velocity at a specific instant. *Initial velocity* and *final velocity* are examples of instantaneous velocity.
    - *Average velocity* is the total (final) displacement in a particular time.

Assessment Guidelines:
The objective of this indicator is to *explain* the relationship among distance, time, direction, and the velocity of an object, therefore, the major primary focus of assessment should be to construct ~~a~~ cause and effect models relating how each variable affects the motion of the object, as well as the effect of combinations of variables on motion.

In addition to *explain*, assessments may require that students:
- *Exemplify* how each variable influences the motion of an object;
- *Compare* distance to displacement and velocity to speed;
- *Summarize* the effect of each variable separately or in combination on the motion of an object; (speed, velocity, time, distance, or displacement)
- *Infer* from experimental data the relative speed or velocity of an object (faster vs. slower);
- *Illustrate* in words pictures or diagrams the effect of these variables on the motion of an object.